

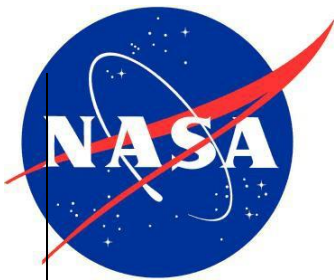
FLIGHT SAFETY PLAN

For

**LONG DURATION BALLOON MISSION
From McMurdo Station, Antarctica
Winter 2018/19/20 Campaigns
Revision A**

**Effective Date
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803/Safety Office



**National Aeronautics and
Space Administration**

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337

FLIGHT SAFETY PLAN

For

Balloon Missions at McMurdo Station, Antarctica

PREPARED BY:

Digitally signed
by Joseph
Weiner
Date:
2019.10.31
08:52:33 -04'00'

Joseph Weiner
803/Flight Safety Analyst

REVIEWED:

Digitally signed
by LINDA WILES
Date:
2019.11.04
09:10:21 -05'00'

Linda Wiles
803/Flight Safety Analyst

APPROVED:

Date:
2019.10.31
08:55:12 -04'00'

Katie Cranor
803/Acting Deputy Chief for Flight Safety

CONCURRED:

Digitally signed by
Lauren Morgan
Date: 2019.10.31
09:04:00 -04'00'

Lauren Morgan
803/Mission Range Safety Officer

CONCURRED:

Digitally signed by
DEBORA FAIRBROTHER
Date: 2019.10.31
16:36:56 -04'00'

Debora Fairbrother
820/Chief, Balloon Program Office

[illegible]

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i. GLOSSARY

AART: Addressable Asynchronous Receive Transmit – Format for serial ports that allows multiple lines into one port.

ARTCC: Air Route Traffic Control Center - A United States facility responsible for controlling instrument flight rules aircraft enroute in a particular volume of airspace at high altitudes between airport approaches and departures.

ACER: Advanced Collar Electronics Radio. The new electronics section of the Collar release system that became operational during the Ft. Sumner campaign in 2018.

ATF: Air Traffic Frequency, assigned transponder code to balloon by ARTCC.

BPO: Balloon Program Office at Wallops Flight Facility that manages the scientific ballooning program conducted via CSBF

CSBF: Columbia Scientific Balloon Facility based in Palestine, TX, provides a permanent complex for scientific balloon flight operations in the form of launching and tracking large (400-ft diameter), unmanned, high altitude (120,000 + ft.) research balloons, and recovering the scientific experiments suspended beneath them.

Critical Operations Personnel: This includes persons not essential to the specific operation (launch, entry, flight) currently being conducted, but who are required to perform safety, security, or other critical tasks at the launch, landing, or flight facility. Critical Operations Personnel are notified of the hazardous operation and either trained in mitigation techniques or accompanied by a properly trained escort. Critical Operations Personnel do not include individuals in training for any job or individuals performing routine activities such as administrative, maintenance, or janitorial. Critical Operations Personnel may occupy safety clearance zones and hazardous areas and need not be evacuated with the public. Critical Operations Personnel are included in the same risk category as Mission Essential Personnel. (Reference Range Safety Manual 2002 Rev. C).

FRR: Flight Readiness Review.

IRT: Interim Response Team, panel assembled to respond should incident occur until a mishap investigation team can be assembled and arrive on site.

Launch Danger Area (LDA): The 500 feet radial buffer area which is added to the Launch Limit Area in order to provide a safety margin for impact of the balloon flight train during an abort. Only mission essential personnel are permitted within the Launch Danger Area during a balloon launch.

Launch Hazard Area (LHA): This is an area about the payload launch vehicle start point designed to provide a safety margin for impact of the balloon during an abort. Center essential personnel and required civilian workers are permitted within the Launch Hazard Area during a balloon launch, provided that these personnel remain within access of or within approved structures as determined appropriate by the MRSO or designee. Roadblocks to prevent non-essential personnel (spectators or passers-by) from entering the Launch Hazard Area will be implemented using roadblock barriers to prevent entry and the area shall be verified to be clear of non-essential personnel and vehicles prior to balloon release from the spool and through the launch phase of flight. The actual size and shape of the LHA is described in Section 3.0.

Launch Limit Area (LLA): The launch hazard zone in which the launch vehicle can maneuver in order to conduct the balloon launch. Only mission essential personnel are permitted within the Launch Limit Area during a balloon launch.

Mission Essential Personnel: Those individuals whose activities contribute directly to the performance of a potentially hazardous operation which is actually under way, and whose presence is mandatory for completion of the operation. (Reference Range Safety Manual 2002 Rev. C).

NSF: National Science Foundation, the entity that runs McMurdo Station and coordinates science events.

PiBal: An abbreviation for pilot balloon, a balloon released and tracked to determine wind speed and direction at various altitudes.

POC: Point of Contact, person with whom to interface for information from other organizations.

Public: For the purposes of range safety risk management, all people who are not Center Essential Personnel. Public includes visitors and personnel inside and outside NASA-controlled property who are not Center Essential and who may be on land, on waterborne vessels, or in aircraft.

SPAWAR: Space and Naval Warfare Systems Command

Tower: The ground-based facility containing the Ground Station Equipment (GSE) suite and associated telecommunications equipment. It is the watch station location for operation command and control personnel.

VecSum: Vector summation of the measured winds. This is calculated from the PiBal data collected before launch.

WFF: Wallops Flight Facility, responsible for all facets of safety as per Range Safety Manual 2002 Rev. C a document generated by WFF stating the range safety requirements in order to implement document NPR 8715.5, Range Flight Safety Program. The Range Flight Safety Program document was written to insure risks are controlled and mitigated.

1.0 FLIGHT SAFETY REQUIREMENTS

1.1 Flight Safety Responsibility

Launch abort authority resides with the Mission Range Safety Officer (MRSO) or designee, Mission Manager (MM), and the CSBF Campaign Manager (CM) /Launch Crew Chief (LCC) depending on the circumstances.

A. Mission Range Safety Officer (MRSO) or designee shall:

1. Establish all operational hazard areas, flight safety limits, and flight termination criteria for balloon missions.
2. Verify that WFF Safety and BPO/CSBF have completed hazard analyses for balloon launch operations for all credible hazards, covering all phases from set-up through termination and recovery.
3. In coordination with the MM, verify air traffic controlling authority has been contacted with ascent vector, descent vector, proposed launch time, and all other pertinent information required by the air traffic controlling authority (if applicable).
4. Coordinate roadblock locations with the MM and CM based on the winds on operation day using the widest sweep out possible to anticipate possible wind changes.
5. Verify CSBF's proper implementation of the hazard areas for the launch site to include Launch Limit Area, Launch Danger Area, and Launch Hazard Area in accordance with this FSP.
6. Confirm through briefing at the Weather Brief, with MM and OSS, that all the possible layout directions are adequately enclosed in the predefined hazard operations area.
7. Monitor radio communications between the CM, Launch Crew Chief, Meteorologist, and reporting status to CM.
8. Maintain communication with the OSS during prelaunch activities and during launch.
9. Provide GO/NO GO call to the CM prior to the start of inflation.
10. Provide FINAL Safety GO/NO GO call to the CM prior to launch.
11. Verify the balloon launch is carried out within the Launch Limit Area, with unquestioned authority in calling for an abort should the launch vehicle breach the Launch Limit Area.
12. Oversee the operations team implementation of the Flight Termination Criteria in accordance with Section 6.0.
13. Call for Flight termination in the event of a launch mishap, overflight risk issue, or other situation creating the need for a termination command decision for purposes of ensuring safety.

14. Coordinate with BPO and CSBF to identify and implement safety risk mitigations on any aspect of a mission that falls outside the specifics of this FSP.
15. Coordinate with CSBF and BPO during Termination Operations to help mitigate public risk in accordance with Section 6 of this document.

B. The CSBF Campaign Manager (CM) has general flight management authority, including flight termination authority for all phases of flight. The CM shall:

1. Conduct pre-flight weather briefings and making decisions to schedule a launch attempt.
2. Ensure exclusion of non-essential personnel from the hazard areas prior to launch.
3. Direct the Launch Crew Chief to abort should the balloon launch appear anomalous, the payload launch vehicle breach the Launch Limit Area boundary, or based upon a call for abort from the MRSO or designee.
4. Be granted flight termination and general flight management authority in all phases of the flight, in accordance with Section 5.0 of this FSP.
5. Coordinate with the MRSO or designee and local authorities to establish and place roadblocks, verifying roadblocks are in place and road between is clear of personnel prior to launch.
6. Coordinate with the MRSO or designee on any aspect of safety, whether pre- or post-launch that falls outside the specifics of this FSP.
7. Coordinate with the MRSO or designee to ensure NASA risk criteria are satisfied during all phases of flight
8. Post-launch, ensure coordination with the MRSO or designee on any aspect of a mission regarding safety risk that falls outside the specifics of this FSP.

C. The Launch Crew Chief (LCC) shall:

1. Implement launch procedures per the NASA approved Ground Safety Plan, Hazardous Procedures, Flight Safety Plan, and CSBF guidelines.
2. Implement the CSBF launch activity within the pre-defined Launch Limit Area, and conduct an abort based upon a call for abort from the CM or MRSO or designee.
3. Conduct a launch abort should the balloon launch appear anomalous.

D. The Balloon Program Office (BPO) Mission Manager (MM) shall:

1. Provide work space, instrumentation and personnel to support safety functions.

2. Serve as the single Point Of Contact between MRSO or designee and CSBF CM on behalf of the BPO COTR, and providing mission safety and project oversight.
3. Facilitate working relationship between the MRSO or designee and CSBF personnel.
4. Facilitate all public risk assessments performed for each mission.
5. Facilitate the GO/NO GO decision process prior to launch.
6. Complete Mission Manager Launch Procedure and providing clearance per the launch commit criteria to the CSBF CM.
7. Identify and brief the roles of the IRT at the FRR.
8. Serve as the Chair of the IRT in the case of a contingency.
9. Ensure that a call for an abort is properly executed and may also initiate an abort.
10. Provide management oversight for each mission.

E. The Operational Safety Specialist (OSS) shall:

1. Observe all hazardous operations as delineated by the Ground Safety Plan.
2. Confirm, with the MRSO or designee and the MM, that the layout direction is adequately enclosed in the predefined hazard operations area.
3. Verify all ground safety limits that are documented in the Ground Safety Plan are observed.
4. Review operations associated with recovery and ensuring the plans and procedures are in place so that the recovery occurs safely.
5. Coordinate and communicate status to MRSO or designee and MM during flight line activities.

1.2 Balloon Termination System Requirements

RSM 2002 Rev C states in Section 6.4.5.1 that a Range Safety System is required, unless the maximum weight and weight per surface area criteria of CFR 14, FAA, Part 101, Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons are satisfied.

The BTS performs as a contingency management system since it was designed as a recovery system of flight hardware. The recovery system does not meet Flight Termination System criteria for reliability (.999 @ 95%). However, an estimate of its reliability as it affects this mission was assessed and documented in **803-FS-RAR-BPO-Ant2018_19-01A**. Failures and resulting risk from this have been analyzed and documented in that risk analysis. The Balloon System Flight Termination System Report (820-FTSR-2011-1) contains a detailed description of the BTS, tailoring summary, design data, reliability data, ground support systems data, test data, and the FTS telemetry data.

The Balloon Termination System (BTS) used on small balloons does not consist of the Universal Terminate Package (UTP) as the standard 4 MCF and larger balloons. The same BARREL Terminate System is used for the commanding and telemetry, which was also used for GUSTO Pathfinder missions successfully in Antarctica in 2018, and the BARREL missions dating back to 2013. The same balloon destruct system is also used, and upon activation, opens the balloon envelope and terminates the flight. CSBF/BARREL has successfully used this termination package on over 55 flights. Information on this BTS can be found in the "BARREL Terminate System Specification Document" found at <\\wff-lynx\Code803NEW\Documents\Working Documents\Flight Safety\Range Users FSDP\Balloons\Antarctica 2019>

1.3 Command System Checks

At the beginning of each campaign, UTP calibration and functional testing takes place according to CSBF flight line checklist, procedure number EC-700-11. Subsequently, each time a launch attempt occurs, all systems are checked once again using the flight line checklist.

CSBF tests the termination system squibs according to CSBF flight line checklist, procedure number ES-100-20-P. The science team PI shall use their Launch Checklist ICE2018 and BARREL Terminate System Flight Readiness Test Procedure BARREL FTP-1xx 121231 checklists to test the BARREL Terminate System. Both of these documents are located at <\\wff-lynx\Code803NEW\Documents\Working Documents\Flight Safety\Range Users FSDP\Balloons\Antarctica 2019> .

The pre-flight checks must be performed, passed, and will be verified by the Mission Manager Launch Procedure via a GO from CSBF operators. BPO and CSBF shall provide the MRSO or designee the opportunity to witness and verify successful completion of these tests both prior to the campaign, and prior to each launch attempt. MRSO/designee witnessing of these tests is at the discretion of the WFF Safety Office.

2.0 OPERATIONAL AREA DEFINITIONS

There is one operational area for Antarctica, the continent and surrounding ocean. For this campaign, the manifest has two missions that are LDB missions and not designed to exit the continent and traverse the ocean to other countries. In addition there are

two small scale super pressure balloons that are allowed to leave the continent and traverse over the ocean.

The planned small scale super pressure balloon (SPB) systems are permitted to float across Antarctica. The risk analysis for this class of balloon systems (803-FS-RAR-BPO-ANT2018/19-01A) has determined that the BPO-provided balloon/payload combinations as described in the risk analysis report are permitted based on bounding cases assessed that show such flights are within the acceptable risk criteria. Once in flight, mission termination is subject to the criteria provided in Section 5 of this FSP.

Small scale SPB systems are defined as balloons that do not exceed 0.6 MCF in volume and 300 lbs. (uninflated) in weight and payloads that do not exceed 74 square feet in calculated lethal area and 200 lbs. in suspended weight. They do not require a payload launch vehicle nor the traditional spool vehicle. They employ a device called the 'hutch clutch' to restrain the balloon prior to release. These systems also do not utilize a collar, nor do they contain any controllable valves. Launch of systems outside the scope of this analysis is not permitted without specific approval by the MRSO or designee.

2.1 Balloon Flight Profile

Fight is restricted to the Antarctica continent and surrounding waterways. Per the CSBF MRR, the balloon systems are permitted to exit the continent, but are not permitted to overfly any populated landmass.

3.0 HAZARD AREAS

3.1 Launch Hazard Area

3.1.1 Balloon System

The Launch Limit Area (LLA) is the launch hazard zone in which the payload launch vehicle can maneuver in order to conduct the balloon launch. It is defined as a 1000 ft. radius circle specifically designed drivable surface area. Only mission essential personnel are permitted within the Launch Limit Area during a balloon launch. The Launch Limit Area border in Antarctica will be defined with visible markings (Snow Flags).

The Launch Danger Area (LDA) is the 500 feet minimum buffer area which is added to the Launch Limit Area in order to provide a safety margin for impact of the balloon flight train during an abort. Only mission essential personnel are permitted within the

Launch Danger Area during a balloon launch. LLA and LDA are graphically represented in Enclosure 1, the launch pad layout. What is shown in the current Enclosure 1 is last year's layout. There will be a new launch facility layout after the site has been surveyed this year by CSBF.

The Launch Hazard Area (LHA) is based on the distance that the aborted balloon may drift buffered by a factor of safety. The LHA shall be a set of enclosed arcs based on wind speed and Factor of Safety. The placement of the arcs shall be based on real-time wind conditions the day of the launch attempt. See table below, and refer to Enclosure 2 for the LHA sectors and distances. What is shown in the current Enclosure 2 is last year's layout. There will be a new launch facility layout after the site has been surveyed this year by CSBF.

Assumptions:

- 1) The Payload Launch Vehicle is at the center of the launch pad layout direction junction.
- 2) The LHA direction is plotted about the VecSum direction.
- 3) Buffer distance assumed is approximately 1000 feet run with payload launch vehicle.

Table 3.1.1 Safety Factors for the Various Wind Speeds

Wind Speed (knots)	Drift Distance (feet)	Factor of Safety (FOS)	LHA Radius = (Drift Distance * FOS) + Buffer	LHA Shape
2	503	1.5	1755 ft / 0.29 nm / 0.53 km	360° about launch direction
6	1509	1.5	3264 ft / 0.54 nm / 1.00 km	±60° about launch direction
12	3018	1.5	5527 ft / 0.91 nm / 1.68 km	±45° about launch direction
16	4024	1.5	7036 ft / 1.16 nm / 2.14 km	±30° about launch direction

There is an initial circle that extends 0.29 nm (1,755 feet) out from the center of the launch pad and is applied for extremely light and variable winds (i.e. < 2 knots) as seen by inspection of Table 3.1.1. The circular sector areas or enclosed arcs described in the following section explain further, if the layout direction is 120° T for the launch toward 300° T, the circular sector areas would be aligned toward 300° T.

Initially, the LHA is plotted opposite of the balloon layout direction, which is provided in Magnetic degrees. The MRSO or designee shall convert this to True degrees based on a declination of $E140.73^{\circ} \pm 0.57^{\circ}$ (<https://www.ngdc.noaa.gov/geomag-web/>). As operations continue, PiBal (pilot balloon) data is used to adjust the LHA based on the VecSum.

The first circular sector area, or enclosed arc, is for a 6 knot wind and extends 0.54 nm (3,264 feet) out from the center of the launch pad and sweeps $\pm 60^{\circ}$ on either side of the nominal layout direction. The second circular sector area extends 0.91nm (5527 feet) out from the center of the launch pad and sweeps $\pm 45^{\circ}$ on either side of the nominal layout direction for a 12 knot wind. The third and last circular sector area extends 1.16nm (7036 feet) out from the center of the launch pad and sweeps $\pm 30^{\circ}$ on either side of the nominal layout direction for a 16 knot wind.

The LHA is to be oriented along the layout direction with the enclosed arcs radiating towards launch direction. The requirement for sheltering personnel can then be determined based on the wind speed and direction of the current PiBal data. This process is to be performed with each PiBal report until launch. There shall be a table to aid the implementation of the LHA with respect to center essential personnel at the LDB site to allow for some variability in wind data.

All non-essential personnel shall be outside the Launch Hazard Area. All center essential personnel not involved in launch operations but required for range operations in the vicinity of the launch site shall be under cover in the payload building farthest from the launch pad – the payload building with less exposed surface area in the direction of the launch pad), as required. This restriction will remain in place until released by the MRSO or designee. All mission essential personnel involved in launching the balloon shall remain upwind or crosswind of the payload launch vehicle out of the drive path. It is acceptable for designated mission essential individuals to be inside the area and on the payload launch vehicle with the responsibilities of driving the Launch Vehicle, keeping the payload under control, and/or manually pulling the launch pin.

To aid in the implementation of the Launch Hazard Areas, a table has been provided as Enclosure 4. This table presents layout azimuths and wind speeds for which sheltering of personnel is required. What is provided in the current Enclosure 4 is based on last year's layout. Enclosure 4 will be updated after the site has been surveyed this year by CSBF.

For small scale balloons, only one cone section shall be used for the Launch Hazard Area. A cone associated with the 12 knot wind shall be aligned to the launch direction and sweeps $\pm 45^{\circ}$ on either side of the nominal layout direction. The arc that extends

0.91 NM (5,527 feet) out from the center of the launch pad and is applied for all wind conditions at launch (up to 6 knots ground wind speed).

3.1.2 Sheltering

The payload building furthest from launch pad is the only sheltering location utilized for a minimum number of mission essential and critical operations personnel only. The sheltering analysis provided by Code 228 did not approve the payload building structures for sheltering purposes from a balloon strike (side-on strike concerns). However the balloon risk analysis performed provides acceptable risk values based on population density and probability of an event occurring as well as probability of impact. See the risk analysis for more information, **803-FS-RAR-BPO-Ant2018_19-01A.docx** in the location <\\wff-lynx\Code803NEW\Documents\Approved Safety Documents>.

The Safety Office requires the personnel be sheltered in the payload building farthest from the launch pad if those personnel are mission essential or critical operations personnel. Otherwise, they are to be evacuated to a location outside of the LHA.

Additionally, the Safety Office requires the occupants of the payload building closest to the pad to relocate to the other payload building to shelter approximately 20 minutes prior to the end of balloon inflation through launch and the "All Clear" given by the MRSO or designee.

There is an allowance made for the minimum number of mission essential personnel that are required to be in the TM building (Electronics Shop) manning workstations at launch.

3.1.3 Restricted Viewing Location

The Safety Office has designated a restricted viewing location to allow a minimum number of science team members directly involved with the current launch to view the launch in the event the LHA encompasses either of the Payload Buildings. The restricted viewing area shall be located between the Payload Building and the Rigging Shop. An area shall be cleared and marked between the buildings to afford a viewing opportunity for the launching science team members to view the launch then immediately proceed into the Payload Building. The Camp Manager shall provide confirmation of compliance to the MRSO or designee.

The restricted viewing area is only usable up until launch. Once the balloon is released from the spool and the payload is released from the launch vehicle, the viewing location is disestablished and any personnel inside the viewing area must move inside

the payload building farthest from the launch pad until released by the MRSO or designee. Should any anomaly occur during the launch process the viewing area is disestablished and personnel shall remain sheltered in the Payload Building.

The principal investigator for each science team shall acknowledge in writing the conditions of utilizing this special restricted viewing area and is responsible for all members of his/her science team abiding by those conditions.

3.2 Aircraft Hazard Areas

3.2.1 Airspace

The CM (or CSBF Operations Manager) must obtain operating approval from the local air traffic controlling agency before launching a balloon. This approval will be a part of the launch checklist or countdown steps and shall be provided to the MRSO or designee. Operational personnel at all sites will adhere to any specified operation or communications requirements stipulated by the ARTCC or local air traffic controlling agency.

The local air traffic controlling agency is SPAWAR.

4.0 FLIGHT SAFETY LIMITS

4.1 Launch Limits

Based on the Balloon Risk Analysis for this campaign for the Long Duration Balloon (LDB) missions, using the standard methodology and the 44% failure rate, there are no overflight restrictions.

Small SPB missions have also been analyzed for this campaign using failure rates for SPBs applied to 100 days at float. The analysis shows that there are no overflight restrictions for these missions. Detailed results of the analysis can be found in 803-FS-RAR-BPO-ANT2018_19-01A section 4.3.

4.1.1 Roadblocks

Roadblock(s) must be in place prior to launch and verified by the MRSO or designee. Coordination of placement and verification will be accomplished with local agencies through the CM. Based on the information provided, only one roadblock is required on the road to the LDB site to restrict traffic into the site but still allow traffic to Williams Field.

4.1.2 Communications

Communications must be maintained between the CSBF Launch Crew Chief on the flight line and the CSBF CM. The CM must maintain communications with the MRSO and MM. The OSS, MRSO, or MRSO designee shall have a separate communication channel and maintain communications if primary channel not available. The MRSO or CM must also have communications with the Camp Manager to verify sheltering requirements have been satisfied if the launch is in the direction of the payload buildings.

4.1.3 Wind Limits

Winds can be measured using standard pilot balloon observations or Launch Crew Chief estimates made by tugging on a tethered balloon at the full height of the flight system depending on what point it is in the count. PiBal data is the desired method from the beginning of the count to as late as 10 minutes prior to the end of inflation. Later than that point in the process the tethered PiBal may be used to confirm there are no significant changes in the previous tracked PiBal data.

Wind speed is defined as the vector summation of wind velocities between the surface and the full height of the flight system including the balloon to a height of 1650 feet unless otherwise agreed upon by the MRSO or designee and CM. Cross wind direction is defined as the angular deviation of the wind vector from the direction the flight train is laid out in.

Wind data is derived by PiBal assessment and observed/forecast data from local observation stations are added to complete the profile. These wind profiles are used to calculate the ascent vector and descent vectors for various termination altitudes from the desired float altitude down to the ground.

Launches will not be attempted unless wind conditions fall within pre-defined limits. Wind limits are defined in terms of speed and the cross wind direction. Cross wind directions are categorized as “nominal” and “off nominal.” Nominal crosswinds are within +/- 40 degrees from the direction the flight train is laid out in. Off Nominal crosswinds are >40 degrees in variance from the direction the flight train is laid out in.

For Nominal crosswind conditions, balloon launches will not be attempted if wind speed exceeds 16 knots.

For Off Nominal crosswind conditions, balloon launches will not be attempted if the wind speed exceeds 16 knots.

Launches for the small SPB missions shall not be attempted if low-level wind speed exceeds 6 knots.

Two key decision points occur during the launch sequence where the winds are evaluated against these criteria: a) prior to inflation when the roadblocks are set, b) prior to the GO/NO GO call by the MRSO or designee for launch. The primary purpose for instituting the wind limits is to ensure the hazard areas being enforced cover any risk to the public and center essential personnel in the area.

Prior to Balloon Inflation:

The CM shall meet with the MRSO or designee to obtain a GO/NO GO for inflation based upon wind limits criteria in Section 4.1.3, (MRSO or designee GO/NO GO). The MRSO or designee may choose to proceed at this point if the criteria are not met, but are expected to be within criteria at the time of launch.

Completion of Balloon Inflation:

The MRSO or designee will use the last PiBal data measurement in conjunction with the tethered balloon data to provide a final GO/NO Go for launch, provided all other MRSO criteria have been met. If GO, the CM will hand over responsibility to the Launch Crew Chief. The MRSO or designee, MM, and CM retain abort authority. Should the meteorology not be within constraints, MRSO or designee will provide a NO GO, and the CM will hold for improved conditions or cancel the launch, based on the CSBF's weather forecast.

4.2 Flight Limits

4.2.1 Position

Based on the balloon risk analysis all proposed mission trajectories are acceptable.

Positional data (present position) is obtained via onboard GPS and displayed on various software and mapping tools in one of the following locations: the McMurdo Remote Operations Control Center or CSBF Operations Control Center. Also displayed will be the descent vectors on the same software and mapping tools simultaneously.

4.2.2 Operational Area Limits

There are no operational area limits for Antarctica with regard to overflight and trajectory for all balloon missions.

It is recommended that there be no planned pressurization over McMurdo Station for the small SPB missions. This serves as a risk mitigation strategy to account for possible

incongruities between applying the conventional ZPB risk to the small SPB missions in the risk assessment process. Per the MRR package provided by CSBF, overflight of populated land masses beyond Antarctica is not permitted.

4.3 Recovery

The descent vector must satisfy the CSBF's standard operating procedures and Flight Safety Risk Assessment Report. If for some reason this cannot be accomplished, it is prudent to conduct termination such that it minimizes risk to the greatest degree possible. See Enclosure #3 for a listing of the CSBF "Population Avoidance Criteria" that dictate the standard operating procedures or "Population Area Avoidance Restrictions."

5.0 FLIGHT TERMINATION

5.1 Flight Termination Criteria

The MRSO or designee, CM, and MM have authority for flight termination throughout all launch and flight phases. At a minimum, the MRSO or designee shall be involved in any planned flight termination decision that falls outside the specifics outlined in this FSP. For any unplanned termination decisions needed to quickly respond to an emergency, CSBF shall work with BPO to execute a safe flight termination in accordance with the termination criteria. An unplanned termination will be coordinated with the MRSO or designee where possible.

Flight termination is to be conducted per the CSBF's standard operating procedures, in accordance with the pertinent Flight Safety Risk Assessment Report, and in such a manner as to protect human safety, and minimize property damage. The termination shall not be performed such that it creates a greater hazard. Upon receiving direction to terminate by the MRSO or designee, the CSBF CM or Launch Crew Chief will take all steps necessary to effect a safe termination as early as possible in order to best ensure safety to people and property.

5.1.1 Launch Phase

5.1.1.1 Balloon Termination

Termination of the balloon must occur if any of the following conditions occur during a launch attempt:

1. The Launch Crew Chief deems that due to changes in range condition, safety, meteorological, scientific, or other balloon flight system conditions, he may then make the decision to cut (abort) the balloon from the spool.
2. The balloon is released from the spool but the payload cannot be released from the launch pin when commanded, thus the Launch Crew Chief assesses that the payload cannot safely be released and therefore will call for an abort.
3. The balloon is released from the spool, but the balloon exhibits anomalous characteristics and the payload is still attached to the payload launch vehicle, then the Launch Crew Chief or CM may call for an abort.
4. The payload launch vehicle travels outside the Launch Limit Area.
5. The payload impacts or drags outside the Launch Limit Area.
6. The payload and/or balloon exhibit gross deviation from expected flight profile or erratic behavior such that the balloon and/or payload may create additional hazards to the public or property.

In all cases, the population avoidance procedure outlined in Enclosure 3 must be observed.

In all cases of termination during ascent, the MRSO or designee will work with the rest of the operations team to implement the termination criteria to the greatest extent possible to minimize safety risk.

Note: There is no collar used on the small SPB during launch. There is no capability to separate the payload from the parachute for these small SPB systems, therefore there is no backup to the balloon abort action. Since these systems are much smaller scale than the larger ZPB systems, this does not pose a significant hazard and should be contained within the conservative LDA for these missions.

5.1.1.2 Separation Command

The command to separate the parachute from the payload must occur if an abort has been called during the launch phase but the balloon fails to abort or fails to disconnect from the parachute. Separation of the parachute from the payload acts as a backup to the balloon abort action. This must occur to limit the travel capability of the payload beyond the Launch Danger Area. The risk associated with a derelict balloon and parachute in Antarctica is mitigated by the LHA clearance, sheltering, and roadblock(s), after which it falls within the negligible risk level.

5.1.2 Overflight

There are no overflight restrictions for the conventional missions unless explicitly stated in Section 2.1.

6.0 RECOVERY

See Section 4.3 Recovery for flight trajectory requirement and see the Ground Safety Plan for specific handling requirements for the payload and balloon systems.

7.0 SUPPORT AIRCRAFT

Not Applicable.

8.0 REVIEWS/BRIEFINGS

All flight safety limits and resulting flight termination criteria shall be presented to the Balloon Program Office and CSBF for the mission. A Mission Flight Readiness Review (FRR) will be conducted in the field prior to conducting launch operations.

The MRSO or designee will participate in Table Top contingency exercises prior to the FRR.

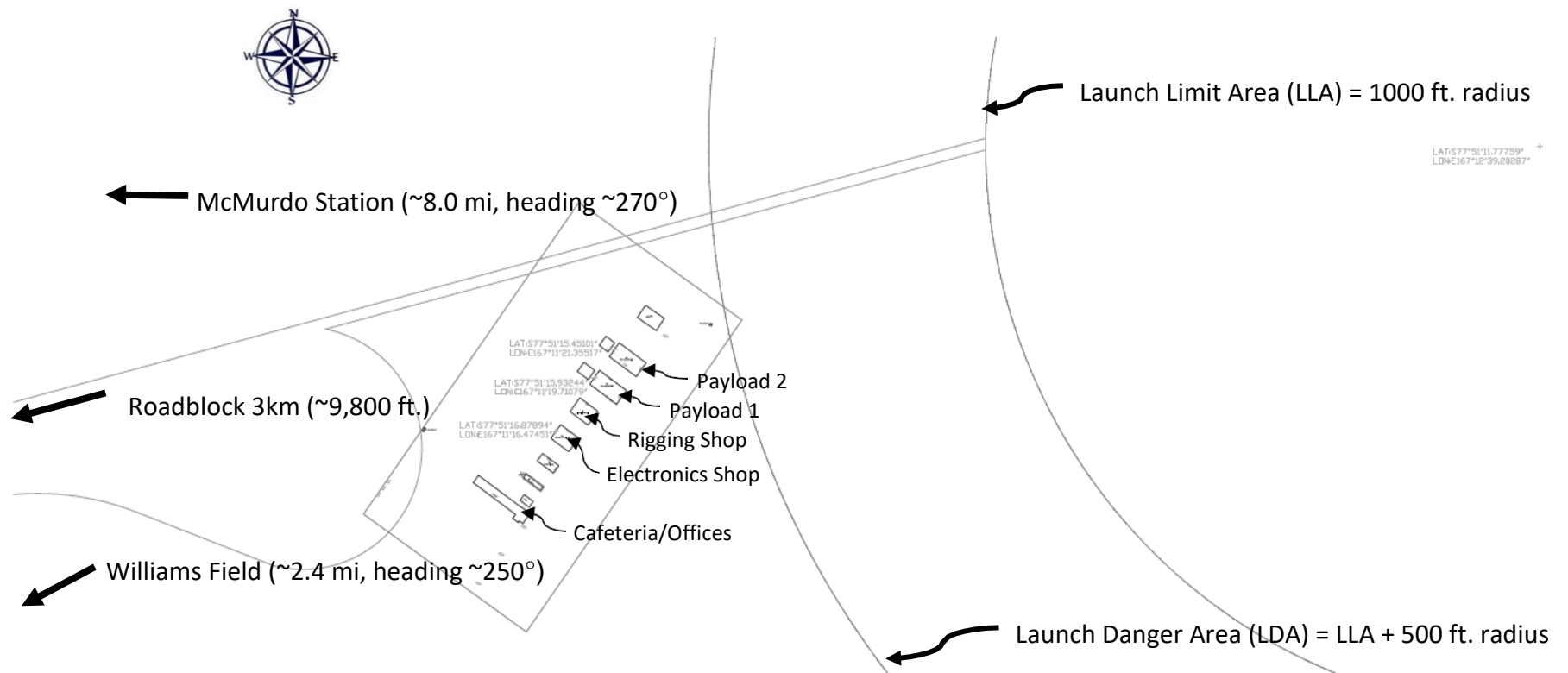
9.0 WAIVERS AND EQUIVALENT LEVEL OF SAFETY (ELS)

An ELS is required to be approved to accommodate science team viewing of launches in the event the Launch Hazard Area overlays the payload buildings.

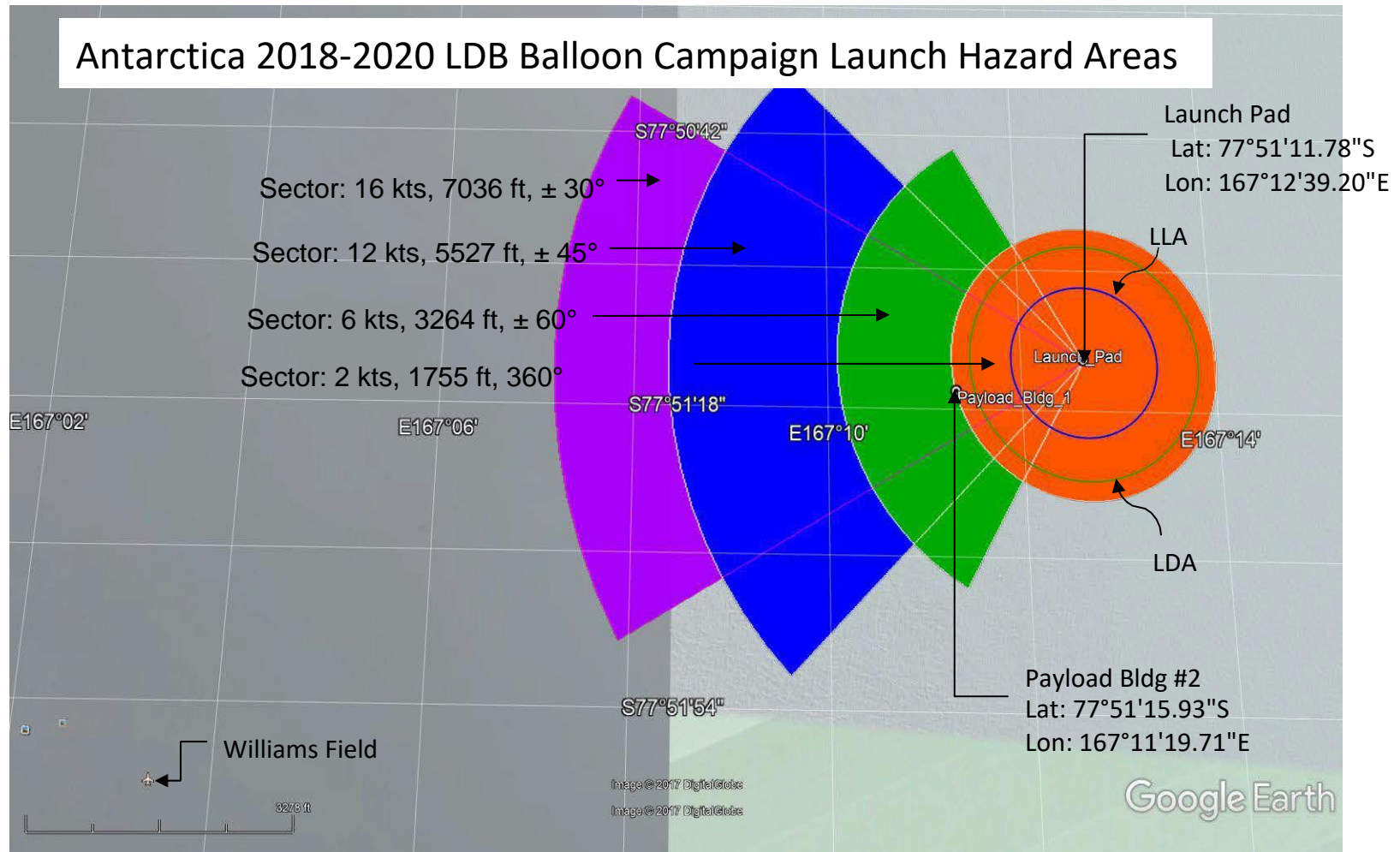
An ELS is required to be approved because a Code 803 MRSO may not serve for the duration of the Antarctica Balloon Campaign. In the event that the Code 803 MRSO does not serve for the duration of the Campaign, the BPO MM shall be assigned to serve as MRSO for the remainder of the Campaign.

ENCLOSURE 1: LAUNCH PAD AREA DRAWING

Antarctica 2018-2020 LDB Balloon Campaign Launch Site Layout



ENCLOSURE 2: EXAMPLE LLA, LDA, AND LHA LAUNCH DIRECTION OF 270° TRUE



ENCLOSURE 3: TOWN AND CITY AVOIDANCE PROCEDURE

Population Avoidance Criteria

Pre-termination planning will assure minimum risk to the public by determining which Termination Category is applicable for normal terminations that projects impact locations and dispersal areas within the following three classes of populated areas. These classes are based on the graphic display of populated areas as shown on NOAA Sectional Aeronautical charts. The examples cited below are taken from the Houston Sectional Aeronautical Chart.

Class 1 Areas

Class 1 areas are very small communities, hamlets, and populated intersections with a population of less than 500.

Class 2 Areas

Class 2 areas are small towns and incorporated villages with populations of 500 to 4,000.

Class 3 Areas

Class 3 areas are large towns, cities, or metropolises with populations of 4,000 and greater.

Population Avoidance Area Restrictions

Termination, predicted impact points, and associated areas must be chosen such that the following criteria are satisfied.

1. No Class 1 area or greater can be within 2 nm of the terminate point when plotted on a ground track.
2. No Class 1 area or greater can be directly under the predicted impact point for the payload or balloon
3. No Class 2 area or greater can be within the payload dispersal area(5 nm radius) or the balloon dispersal area
4. No Class 3 area can be with the payload buffer area (10 nm radius) or the balloon buffer area.

ENCLOSURE 4: LAUNCH HAZARD AREA IMPLEMENTATION TABLE

This table information is based on minimal survey data and buffering.

Layout Direction True (Degrees)	Balloon Climbout Direction True	Sheltering Required	Vector Summation Wind Speed and LHA arc size
***000-359	000-359	Yes	0-1.9 knots, 360 deg
000-009	180-189	No	2-5.9 knots, +/- 60 deg
010-140	190-320	Yes	
141-359	321-179	No	
000-024	180-204	No	6-11.9 knots, +/- 45 deg
025-125	205-305	Yes	
126-359	306-179	No	
000-039	180-219	No	12-15.9 knots, +/- 30 deg
040-110	220-290	Yes	
111-359	291-179	No	
000-054	180-234	No	16.0-22 knots, +/- 15 deg
055-095	235-275	Yes	
096-359	276-179	No	

These azimuth corridors are based on survey and mapping data provided by ASC (Antarctic Support Contract) for the 2017/8 launch season. The bearing and range from the Launch Pad center to Payload #1 is 257.4 ° at 0.28nm. The bearing from the Launch Pad center to the TM building is 253.8 ° at 0.301nm. The TM building houses mission essential personnel during launch. Payload #2 building is between the two at 256.03° at 0.288nm and no other building shall house any personnel during launch. The layout azimuths of 070° to 080° requires sheltering (launch azimuths of 250° to 260°) . There is buffer of approximately +/- 2 degrees on the layout/launch azimuth range. If the LHA plot results in the line cutting or overlaying a building, the personnel shall be sheltered to allow for uncertainties. Only the Payload Building farthest from the launch pad is an allowed sheltering location for center essential personnel.

The addition of the WeatherPort Building also requires its evacuation during launch activities. All personnel located in the WeatherPort Building shall be relocated to other locations for all launches other than Hand Launched Balloons. The site has been surveyed as to building locations or the pad center. All building locations remain in the same orientation and relationship to the launch pad as in the past. Based on the updated coordinates, the Payload Building#1 falls within the 2k not circle, therefore sheltering is required during all launches with those wind conditions. For wind conditions greater than 2 knots, the applicable arc is to be applied according to layout direction. Conservatism shall be used in implementing sheltering requirements by MRSO or designee.